Saskatchewan

A D F

Agriculture Development Fund

FINAL REPORT

20010266

DETERMINATION OF SOLID MANURE VOLUME GENERATION FOR THE SASKATCHEWAN FEEDLOT AND BEEF INDUSTRY

Funded by
The Agriculture Development Fund

November, 2002
Prepared by: Western Beef Development Centre
&
Prairie Agricultural Machinery Institute

SAF
Saskatchewan Agriculture & Food
Adding value to agriculture...through research and development

AGRICULTURE DEVELOPMENT FUND
RECEIVED
OCT - 1 2002
REGINA, SASK.
S4S 0B1
PROVINCE OF SASKATCHEWAN

Project No. 5002E
Date: September 30, 2002
Tested at Humboldt

ADF#20010266

Final Report

Determination of Solid Manure Volume Generation for Saskatchewan Feedlot and Beef Industry

On Behalf of
Western Beef Development Centre

Nathan Gregg
Project Technician
Technical Services

Darrell Lischynski, P.Eng.
Manager
Energy and Processing

Philip Leduc, P.Eng.
Senior Manager
Research and Development

James Wassermann, P.Eng.
Vice President
Saskatchewan Operations

p:\research\2002\5002e - solid manure\report_proposal\5002e-final.doc

Acknowledgement

PAMI wishes to acknowledge the funding support provided by the Agriculture Development Fund of Saskatchewan Agriculture, Food and Rural Revitalization.

103-04290/

1. Summary

This project is being done as a first step to update solid manure volume generation data for Saskatchewan feedlots. A review of existing literature revealed that not much is known about the origin of accepted values in many jurisdictions. If the accepted manure production values are to be reviewed or updated, more research is needed to gather actual data. A system that uses a combination of feed characteristics and known feed conversion efficiencies to predict nutrients in the manure could also be considered at this time. Manure production data from Saskatchewan feedlots was varied and, in most cases, values were lower than the accepted standards.

2. Technical Report

2.1 Introduction

Present manure volume generation values for feedlots are based on data that may not reflect present day practices and management strategies. This project is a first step to updating solid manure volume generation data. This will ensure that feedlot expansion in Saskatchewan is done in an environmentally and economically sustainable manner.

2.2 Objectives

The objectives of this project are to:

1. Compile, review, and evaluate the existing published and non-published data relevant to cattle manure volume generation.
2. Examine existing standards and guidelines developed by Saskatchewan and the adjacent Provinces and States to determine their appropriateness to Saskatchewan's conditions.
3. Collect, summarize, and interpret historic manure production data from a minimum of six existing feedlot operations in Saskatchewan.
4. Recommend preliminary manure volume production guidelines for Saskatchewan, based on the evaluation of the above data and analysis.
5. Identify further research needed to improve the preliminary guidelines developed in this study phase.

2.3 Project Activities

This project consisted of two main activities. The first was to review existing literature to determine the accepted standard manure production values in several jurisdictions and try to determine the source of the these values. Other technical publications on this topic were also reviewed. All of this data was compiled and compared.

The second activity was to collect manure production data from six feedlots within Saskatchewan. The feedlots were of varying sizes and from varied locations within the province. In some cases, information on feed and bedding material was also obtained, but the vital data collected from each feedlot was the amount of manure hauled out and the head-days.

2.4 Project Results

2.4.1 Literature Review

Several technical papers, handbooks, and guides have been investigated from various jurisdictions, including Saskatchewan, Alberta, several states, Canada, and New Zealand. The results for this research are given in **Table 1**.

Table 1. Accepted Standard Manure Production Summary.

	Source	Jurisdiction	Manure Production (kg/1000 kg animal)			
			"As Excreted"		Other	
			Daily (kg)	Annual (kg)	Daily (kg)	Annual (kg)
1	A Guide to Animal Manure Disposal in Alberta - AB Ag, ~1971	AB	47	17000		
2	Beef Manure Management - Alberta Agriculture Food and Rural Development	AB	11.8 18.0	4307.0 6570		
3	Code of Practice For Responsible Livestock Development & Manure Mgmt	AB	11.8 18.0	4307 6570		
4	Code of Practice For The Safe and Economic Handling of Animal Manures	AB	11.8 18.0	4307 6570		
5	Feedlot Waste Management manure production data - Queensland Gov.	Australia	60	21900		
6	Canada animal waste management guide - Can. Comm. on Ag Eng, 1972	Canada	52	18858	62	22630
7	Canada animal manure management guide - Can. Comm. on Ag Eng, 1979	Canada	52	18851	62	22648
8	Canadian Farm Buildings Handbook - Agriculture Canada, 1988	Canada			56 68	20330 24687
9	Disposal of Animal Wastes - F.R. Hore, Engineering Res. Service, Ag Canada	Canada	52	18858	62	22630
10	Engineering in Animal Manure Handling, F.R. Hore, et al.	Canada	52	18858	62	22630
11	Agricultural Waste Manual- Properties of agricultural wastes- D. H. Vanderhorn	New Zealand	*80*	*29200*		
12	Guidelines for Manure Management For Prince Edward Island: Manure Storage	PEI	56	20330	68	24687
13	Manual for: Developing a Manure and Dead Animal Mngmt Plan - SAF	SK	58	21088.9		
14	Agricultural Waste Management Field Handbook, Chp. 4 - USDA, 1992	USA	59	21571.5	17.5 5.3	6387.5 1934.5
15	Agricultural Waste Management Field Manual- USDA, SCS	USA	62	22630		
16	ASAE Standard D384.1 Dec. 99 Manure Production and Characteristics	USA	58	21170		
17	Energy, Agriculture and Waste Management - Jewell, 1975	USA	60	21799		
18	Feedlot Manure Management - Davis, Stanton, and Haren. #1.220	USA	63	23000	9	3200
19	Fertilizing Cropland with Beef Manure - Michael Schmitt and George Rehm	USA	60	21900		
20	Manure Characteristics -Manure Mngmt Systems Series, Midwest Plan Service	USA	73	26545	17.5 5.3	6387.5 1934.5
21	Manure Production Rates - www.rec.udel.edu/nutrient/excel/LargeAnimal.xls	USA	59	21571.5		
22	Manure Testing - FS430, H.L. Brodie & V. Allan Bandel	USA	60	21900		
23	Nutrient Manager - Making the most of Manure, Vol. 1, 1994	USA	60	21900		
24	Physical Properties of Animal Manures Associated with Handling - A.T. Sobel	USA	*55*	*23758*		
25	Total Manure Production in Texas, Year 2000 Estimates - Texas A&M Univ.	USA	82 60	29930 21900		

Most of the above sources state a manure production of between 50 and 60 kg/1,000 kg animal/day. Some of the above sources reference each other, and many of them reference the ASAE standard D384.1 as their source. In some cases, it is not stated where the values originate. When attempting to find the root source of the values used, none could be found. This is to say that there were no technical papers or other scientific sources found that would verify the manure production values used by many jurisdictions in North America and other parts of the world. The manure production values in use may be correct, but there is no way of knowing this without further research. These manure production values may also be based on earlier production practices and animal genetics that no longer exist. Again, future research is the only practical way to confirm or deny the existing accepted manure production values for many jurisdictions in North America and abroad.

Some other issues arose during this literature review that cause some degree of confusion. For instance, some values are specified "as excreted", and some are "as removed", and there is a large difference between two. The "as removed" values are much lower and are not defined in terms of moisture content, storage time, or other factors. Many sources simply state that the values are "manure production" and do not define if they are "as excreted" or "as removed". Some sources also state different values for open vs. paved lots, or surfaced vs. unsurfaced lots. In some cases, the open or unsurfaced lots have a greater manure production stated and in other cases it is lower. Some values are also listed on a per animal basis with no definition of animal size and others are stated per 1,000 lb or kg of animal weight. Another variable is the animal's diet, as some sources state different manure production values for high forage vs. high-energy diets. All of the above factors may contribute to the variability in the stated manure production values and should be considered if standards are being updates or developed.

One interesting anomaly to the data in **Table 1** is the province of Alberta. The accepted manure production values were 46.6 kg/1,000 kg animal/day in 1971, then dropped to 11.8 kg/1,000 kg animal/day in 1995. The people involved with developing these values indicated that they are based on a combination of a literature review and industry input. If Alberta's experience is that these manure production values are real and result in sustainable levels of nutrients applied to the land, this could give other jurisdictions reason to consider altering their accepted values.

A group within ASAE (American Society of Agricultural Engineers) along with the federation of Animal Science Society are investigating this very topic. Their approach was to first attempt to verify the source of the values used in ASAE standard D384.1. This research did not yield many concrete conclusions, so another approach is now being investigated. Enough is now known about nutrients in feed and the conversion of these nutrients within an animal's body, that the amount of nutrients excreted can now be predicted with a good degree of reliability. Although there are inaccuracies in this method, there are also inaccuracies in measuring quantities and characteristics of manure in a pen because so many factors, such as weather, bedding, diet, timing, animal density, and other factors affect the manure characteristics.

Manure characteristics within a pen are also known to be highly variable, which introduces more potential inaccuracies (USDA Animal Waste Management Field Handbook). If a system that calculated nutrients in the manure based on inputs and animal performance was adopted, other advantages would also exist. Animals that are making better use of their feed will grow faster and excrete less nutrients. Both of these should encourage producers to manage their feed composition and feed conversion very closely to maximize overall feed efficiency. The net result may be that more nutritionists will be employed in the feedlot industry, and that a more productive and efficient industry and more environmentally responsible management of nutrients will occur within the animal production system. This system may also be capable of rewarding producers who manage their nutrients in their system by requiring less land on which to apply the manure because the manure will contain less nutrients. All of the above points should be considered when a revision of the accepted manure production values is conducted.

2.4.2 Saskatchewan Feedlot Survey

Over 20 feedlots in Saskatchewan were contacted in an attempt to obtain whatever manure production data may be available. Of these contacted, data was obtained from six feedlots. In most cases, manure production data was not collected by the feedlots so it was simply not available. A description of all participating feedlots is given in **Table 2**.

Table 2. Cooperating Feedlots.

Name	Location	No. of Head (approx.)
Hi-Lite Custom Feedlot	Melfort	4,500
Gregg Farm Ltd.	Paynton	600
Poundmaker Agventures	Lanigan	28,000
Hebert Land and Cattle Co.	Fairlight	1,200
S&H Buckle Feedyards	Yorkton	2,500
Red Coat Cattle Feeders Inc.	Hazenmore	10,000

In some cases, the manure production data was obtained by counting truckloads and multiplying by an average truckload net weight. In other cases, all or a portion of the trucks hauling manure were actually weighed. In all cases, manure moisture content was not known, and in some instances, bedding was included in the total amounts. All of the above considerations demonstrate that this data may not be comparable from site to site, but it is a good collection of actual data from actual situations, and is therefore the best that can be done to get a quick indication of actual manure production. Results from this exercise are given in **Table 3**. To make results comparable, an average animal weight of 1,000 lb was used. It should be noted that to keep the data anonymous, the order of presentation in **Table 3** may not match the order in **Table 2**.

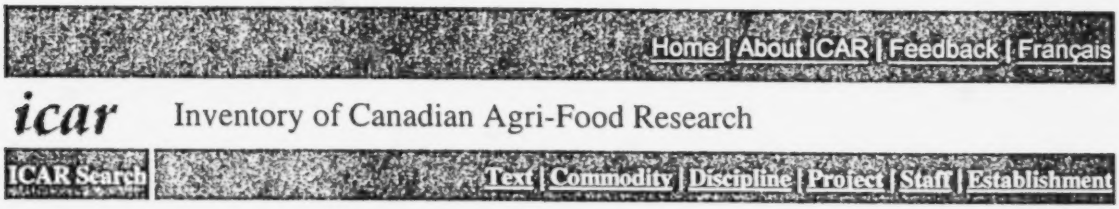
Table 3. Manure Production Data.

Feedlot No.	Manure Production (kg/1,000 kg animal/day)
1	22.0
2	17.6
3	63.9
4	44.1
5	35.3
6	4.4

In almost all feedlots the actual manure produced was less then the ASAE standard of 58 kg/1,000 kg animal/day. In many cases, the actual amounts were much lower than the ASAE standard, and the results are very variable. The data from feedlot six was very low, but this may have been due to the very dry summer that year, resulting in very low manure moisture content. This re-emphasizes the notion that more research is needed if the accepted standards are to reflect actual present day practices.

9. ICAR Data Entry

This project has been entered in the ICAR database with Entry No. 3333 0919. A printout of the entry appears below.


Home | About ICAR | Feedback | Français
icar
Inventory of Canadian Agri-Food Research
ICAR Search
Text | Commodity | Discipline | Project | Staff | Establishment

Title: **Determination of solid manure generation for Saskatchewan feedlot and beef industry**

Objectives: The objective of this project is to determine the amount of solid manure generated by feedlots and backgrounding lots in Saskatchewan. This will help to ensure that new feedlots and expanding feedlots have the correct amount of land available for sustainable manure application. The project will involve a thorough literature review to gather information on methods of determining manure volumes and to compare manure generation volumes used in other jurisdictions. Historical data will also be gathered from as many existing feedlots as possible as a baseline data set. A data collection system will be set up to determine manure generation quantities from several feedlots over a four-year period. Additional data to be collected will include feed input, bedding, management practices and other relevant data. The results of this project will be reliable manure volume generation data that can be used to ensure that feedlot expansion in Saskatchewan can progress in an environmentally and economically sustainable manner.

Status Report: No information available.

Impact: No information available.

Keywords: Beef

Feedlot

Manure

Establishment: WESTERN BEEF DEVELOPMENT CENTRE

Room 203, 105 North Road

Saskatoon, Saskatchewan

S7N 4L5

Web Address: N/A

Staff:

Name	Role	Project PY
Lardner B	PROJECT LEADER	00.00
Lischynski D	ESTABLISHED RESEARCHER	00.00

Contact: Lardner B **Tel:** 306-933-5700 **Fax:** 306-966-2614

9. ICAR Data Entry

This project has been entered in the ICAR database with Entry No. 3333 0919. A printout of the entry appears below.

Home | About ICAR | Feedback | Français

icar Inventory of Canadian Agri-Food Research

ICAR Search Text | Commodity | Discipline | Project | Staff | Establishment

Title: **Determination of solid manure generation for Saskatchewan feedlot and beef industry**

Objectives: The objective of this project is to determine the amount of solid manure generated by feedlots and backgrounding lots in Saskatchewan. This will help to ensure that new feedlots and expanding feedlots have the correct amount of land available for sustainable manure application. The project will involve a thorough literature review to gather information on methods of determining manure volumes and to compare manure generation volumes used in other jurisdictions. Historical data will also be gathered from as many existing feedlots as possible as a baseline data set. A data collection system will be set up to determine manure generation quantities from several feedlots over a four-year period. Additional data to be collected will include feed input, bedding, management practices and other relevant data. The results of this project will be reliable manure volume generation data that can be used to ensure that feedlot expansion in Saskatchewan can progress in an environmentally and economically sustainable manner.

Status Report: No information available.

Impact: No information available.

Keywords: Beef

Feedlot

Manure

Establishment: WESTERN BEEF DEVELOPMENT CENTRE

Room 203, 105 North Road

Saskatoon, Saskatchewan

S7N 4L5

Web Address: N/A

Staff:

Name	Role	Project PY
Lardner B	PROJECT LEADER	00.00
Lischynski D	ESTABLISHED RESEARCHER	00.00

Contact: Lardner B **Tel:** 306-933-5700 **Fax:** 306-966-2614

E-Mail Address: blardner@agr.gov.sk.ca

Cooperating Establishment: - PRAIRIE AGRICULTURAL MACHINERY INSTITUTE, P.O. Box 1150, Humboldt, Saskatchewan, SOK 2AO

Funding Source: - SASKATCHEWAN DEPARTMENT OF AGRICULTURE AND FOOD, AGRICULTURE DEVELOPMENT FUND, Walter Scott Building, 3085 Albert Street, Regina, Saskatchewan, S4S 0B1

Key Code Pairs:

- Animals, Beef Cattle (02020000)
- Animal Management, Animal By-Product Management, Manure And Waste Management (57050400)

- Animals, Animal Products And By-Products, Manure, Beef Cattle (02400702)
- Animal Management, Animal By-Product Management, Manure And Waste Management (57050400)

Start Date:	2002/03/21	**Expected End Date:**	2002/09/30
Project Number:	N/A	**ICAR-ID:**	33330919
ICAR Version (Year):	2002		

© 1999 CARC. All rights reserved.

carc Canadian Agri-Food Research Council
crac Conseil de recherches agro-alimentaires du Canada

Appendix I

Bibliography

1) Agriculture Canada. 1979. Canada Animal Manure Management Guide. Publication 1534. Ministry of Supply and Services Canada.
2) Agriculture Canada. 1988. Canadian Farm Buildings Handbook. Publication 1822E. Ministry of Supply and Services Canada. Table 16, p. 33.
3) Alberta Agriculture, Food and Rural Development. 1995. Manure design volumes for various livestock types. Appendix B. *In* Code of Practice for the Safe and Economic Handling of Animal Manures. Edmonton, Alberta, Alberta Ag. Publishing Branch, p. 21.
4) Alberta Agriculture, Food and Rural Development. 2000. Manure production volumes for various livestock types. Appendix B. *In* Code of Practice for Responsible Livestock Development and Manure Management. Edmonton, Alberta, Alberta Agriculture, Information Packaging Centre, p. 36-37.
5) Alberta Agriculture. n.d. A Guide to Animal Manure Disposal in Alberta. Edmonton, Queen's Printer.
6) ASAE Standards. Manure production and characteristics. ASAE D384.1 DEC 99. American Society of Agricultural Engineers.
7) B. West, West Peak Consulting Services, personal communication, September 26, 2002.
8) Brodie, H. L., V. Allan Bandell. Manure testing. University of Maryland, College of Agriculture and Natural Resources. Accessed July 19, 2002. www.agnr.umd.edu/MCE/Publications/Publication.cfm?ID=318&cat=3.
9) Canada Committee on Agricultural Engineering. 1972. Canada Animal Waste Management Guide.
10) Davis, J.G., T.L. Stanton, and T. Haren. 2002. Feedlot manure management. Table 3. Colorado State University, University Cooperative Extension. Accessed September 26, 2002. www.ext.colostate.edu/pubs/livestk/01220.html.
11) Eigenberg, R.A., R.L. Korthals, J.A. Nienaber, and G.L. Hahn. 1998. Implementation of a mass balance approach to predicting nutrient fate of manure from beef cattle feedlots. *Applied Engineering in Agriculture*, Vol. 15(5): 475-484.
12) Feedlot waste management: manure production data. Queensland Government, Department of Primary Industries, Officers of the Intensive Environment Management Services. University of Maryland, College of Agriculture and Natural Resources. Accessed June 17, 2002. www.dpi.qld.gov.au/environment/5166.html.

APPENDIX I

13) Guidelines for manure management for PEI: manure storage. Accessed August 13, 2002. www.gov.pe.ca/af/agweb/library/documents/manureguide/index.php3.
14) Hore, F.R. 1970. Disposal of animal wastes. *In* Proceedings Environmental Management for the Public Health Inspector. Dalhousie University.
15) Hore, F.R., J. Pas, H. Nodwell, and N. Bird. 1972. Engineering in animal manure handling. *Soils and Crops*: 77-82.
16) Ifeadi, C.N. J.B. Brown, Jr. 1975. Technologies suitable for recovery of energy from livestock manure. *In* Jewell, William J. (ed.). Energy, Agriculture and Waste Management. Ann Arbor, Ann Arbor Science Publishers Inc., p. 373-396.
17) Making the most of manure. *Nutrient Manager*, Vol. 1, Issue 1, 1994. Accessed June 17, 2002. www.agnr.umd.edu/users/agron/nutrient/Factshee/Manure/mostman.html.
18) Manure nutrient standards. Beef Manure Management. Alberta Agriculture, Food and Rural Development. 1996. Accessed June 19, 2002. www.agric.gov.ab.ca/livestock/beef/manur01.html.
19) Midwest Plan Service (MWPS). 2000. Manure Characteristics. MWPS-18 Section 1, Manure Management Systems Series. Ames, Iowa, Iowa State University.
20) NZAEI. 1984. Freshly voided manure characteristics – typical volumes. *In* Vanderholm, Dale H. (coordinator). Agricultural Waste Manual. NZAEI Project Report No. 32. Lincoln College, Canterbury, N.Z. Table 2.3; Chapter 2.
21) Powers, W.J., H.H. Van Horn. 2001. Nutritional implications for manure nutrient management planning. *Applied Engineering in Agriculture*, Vol. 17(1): 27-39.
22) Saskatchewan Agriculture and Food (SAF). 1997. Guidelines for Establishing and Managing Livestock Operation. Regina, SAF, Livestock and Veterinary Operations Branch.
23) Saskatchewan Agriculture and Food (SAF). 1997. Manual for: Developing a Manure and Dead Animal Management Plan. Regina, SAF, Agricultural Operations Section.
24) Saskatchewan. 1995. An Act Respecting Agricultural Operations. Ch. A – 12.1. Regina, Queen's Printer.
25) Schmitt, Michael, George Rehm. 1998. Fertilizing cropland with beef manure. University of Minnesota, Extension Service. Accessed August 13, 2002. www.extension.umn.edu/distribution/cropsystems/DC5882.html.
26) Shipley, Paul. Manure production rates. Excel spreadsheet. Animal Waste Quality Estimate. University of Delaware, Nutrient Management, Cooperative Extension. Accessed July 18, 2002. www.rec.udel.edu/nutrient/page4.html.
27) Sobel, A.T. 1996. Physical properties of animal manures associated with handling. *In* Management of Farm Animal Wastes. ASAE, St. Joseph, MI, p. 27-32.
28) Total manure production in Texas, Year 2000 Estimates. TAMMI-Texas Animal Manure

Management Issues, Texas A&M University. Accessed September 27, 2002. http://tammi.tamu.edu.

29) United States. Soil Conservation Service. 1975. Agricultural Waste Management Field Manual. Washington, USDA.

30) United States. Soil Conservation Service. 1992. Agricultural waste characteristics. *In* Agricultural Waste Management Field Handbook. Chapter 4: 1-24. Accessed June 17, 2002.
www.ftw.nrcs.usda.gov/awnfh.html
or //tammi.tamu.edu/pdf%20pubs/contents.pdf

APPENDIX II

Appendix II

Manure Production Value Details

	Source	Possibly Derived from	Jurisdiction	Manure Production (kg/1000 kg animal) "As Excreted" Daily (kg)	"As Excreted" Annual (kg)	Other Daily (kg)	Other Annual (kg)	
1	A Guide to Animal Manure Disposal in Alberta - AB Ag,		AB	47	17000			
2	Beef Manure Management - Alberta Agriculture Food and	Code of Practice For The Safe and Economic Handling of Animal	AB	11.8 18.0	4307.0 6570			Unsurfaced Feedlot Manur Surfaced Feedlot Manure
3	Code of Practice For Responsible Livestock Development & Manure	Code of Practice For The Safe and Economic Handling of Animal	AB	11.8 18.0	4307 6570			Open lot) Paved lot)
4	Code of Practice For The Safe and Economic Handling of Animal		AB	11.8 18.0	4307 6570			Open lot) Paved lot)
5	Feedlot Waste Management manure production data -		Australia	60	21900			
6	Canada animal waste management guide - Can. Comm.	Canadian Code for Farm Building, 1970.	Canada	52	18858	62	22630	Manure and Bedding
7	Canada animal manure management guide - Can. Comm.	Canada animal waste management guide; Canadian	Canada	52	18851	62	22648	Manure and Bedding
8	Canadian Farm Buildings Handbook - Agriculture Canada,		Canada			56 68	20330 24687	Manure Manure and Bedding
9	Disposal of Animal Wastes - F.R. Hore, Engineering Res. Service,	Engineering in Animal Manure Handling, F.R. Hore, et al.	Canada	52	18858	62	22630	Manure and Bedding
10	Engineering in Animal Manure Handling, F.R. Hore, et al.	Disposal of Animal Wastes - F.R. Hore, Engineering Res. Service,	Canada	52	18858	62	22630	Manure and Bedding
11	Agricultural Waste Manual- Properties of agricultural wastes-		New Zealand	*80*	*29200*			*Dairy*
12	Guidelines for Manure Management For Prince Edward	Canadian Farm Buildings Handbook - Ag Canada, 1988	PEI	56	20330	68	24687	Manure and Bedding
13	Manual for: Developing a Manure and Dead Animal Mngmt Plan -	ASAE Standard D384.1 Dec. 99 Manure Production and	SK	58	21088.9			
14	Agricultural Waste Management Field Handbook, Chp. 4 - USDA,	Agricultural Waste Management Field Manual- USDA, SCS	USA	59	21571.5	17.5 5.3	6387.5 1934.5	Unsurfaced Feedlot waste Surfaced Feedlot waste
15	Agricultural Waste Management Field Manual- USDA, SCS		USA	62	22630			
16	ASAE Standard D384.1 Dec. 99 Manure Production and	ASAE Standard D384.1 Dec. 93 Manure Production and	USA	58	21170			
17	Energy, Agriculture and Waste Management - Jewell, 1975		USA	60	21799			
18	Feedlot Manure Management - Davis, Stanton, and Haren.		USA	63	23000	9	3200	At time of spreading
19	Fertilizing Cropland with Beef Manure - Michael Schmitt and	Livestock Waste Facilities Handbook, Midwest Plan Service,	USA	60	21900			
20	Manure Characteristics -Manure Mngmt Systems Series, Midwest		USA	73	26545	17.5 5.3	6387.5 1934.5	Unsurfaced Feedlot wast) Surfaced Feedlot waste)
21	Manure Production Rates - www.rec.	Agricultural Waste Management Field Manual- USDA, SCS	USA	59	21571.5			
22	Manure Testing - FS430, H.L. Brodie & V. Allan Bandel		USA	60	21900			
23	Nutrient Manager - Making the most of Manure, Vol. 1, 1994	Manure Testing - H.L. Brodie & V. Allan Bandel	USA	60	21900			
24	Physical Properties of Animal Manures Associated with		USA	*65*	*23758*			*Dairy*
25	Total Manure Production in Texas, Year 2000 Estimates -		USA	82 60	29930 21900			Beef Steer